Coastal Engineering Technical Note

SHORELINE MODELING SYSTEM (SMS) Version 1

PURPOSE: This note discusses a microcomputer-based software package that contains a collection of generalized computer programs assembled to enable the user to perform complete longshore sediment transport processes and shoreline evolution assessments. This software package was developed at the Coastal Engineering Research Center (CERC) to facilitate the technology transfer of recently developed coastal engineering tools throughout the Corps.

BACKGROUND INFORMATION: The SMS Version 1 contains two major coastal processes numerical models: GENESIS (Hanson and Kraus 1989; Gravens, Kraus and Hanson 1991) and RCPWAVE (Ebersole 1985; Ebersole, Cialone and Prater 1986); two special purpose data visualization programs for processing output from GENESIS and RCPWAVE; twelve system-support programs for data preparation, analysis, and numerical model input generation; one general purpose graphics program; and two special purpose editors for generation or modification of model configuration input data files. The system-support programs were specifically developed to automate and standardize the typical data preparation and analysis tasks encountered in the course of conducting a shoreline evolution study, beginning with the user's original data source and concluding with input data sets (files) for GENESIS.

Shoreline change models in general, and GENESIS (Hanson and Kraus 1989) in particular, are designed to describe the long-term planform evolution of the beach in the course of its approach to equilibrium in response to imposed wave conditions, boundary conditions, coastal structures, and other engineering activities. In recent years numerical shoreline change models have become an increasingly popular tool for investigating impacts of proposed coastal projects. Specifically, shoreline change models are ideally suited for tasks involving analysis and evaluation of coastal projects with regard to long-term fate of beach fills, feeder beaches, renourishment cycles, and coastal structures designed to enhance the longevity of placed beach fill material.

The accuracy and reliability of a shoreline change simulation are directly related to the quality and completeness of input data sets. With regard to GENESIS, operation of the model requires preparation of as many as seven input data files. These input data streams include model setup specifications (spatial and temporal ranges of the simulation, and model calibration parameters), project reach specification (including boundary conditions, coastal structures, and beach fill configurations within the project reach), shoreline position data, and wave information from which longshore sand transport rates are calculated to compute shoreline change.

Preparation and analysis of input and output data streams occupy a substantial portion, perhaps a majority, of the time spent on a GENESIS project. The importance of this aspect of the modeling process cannot be overemphasized for two reasons:

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The data organization and analysis process itself forms the first basic level of understanding of coastal processes at the project site.

The simulation results must be interpreted within the context of regional and local coastal processes, and the natural variability of the coastal system.

Preparation of data streams needed to run GENESIS and interpretation of simulation results form the backbone of the process of conceptualizing a project. The degree of success in a shoreline change modeling effort to a large extent depends on preparation and analysis of input data that almost always requires use of computer programs. Thus, the SMS was developed to facilitate use of GENESIS throughout the Corps regardless of the user's computer programming capabilities.

STRUCTURE OF SMS: The SMS operates within a specific directory structure as outlined in Figure 1. This directory structure was designed to enable efficient upgrading of the various individual components of the modeling system and the user need not necessarily be familiar with the directory structure. Of more direct interest to the user is the multi-level menu system of the SMS. Individual computer programs within the SMS are executed by highlighting a menu option using either cursor keys or mouse and then pressing the ENTER key. Figure 2 shows the available options at each of the four menu levels. When the SMS is started, the user is initially in the level 1 menu. By default the right-most menu option is highlighted. At this point the user can select any of five available menu options by using either the cursor keys or a mouse to highlight the desired menu option and then pressing the ENTER key. A summary of the operation performed for each of the menu options follows.

SMS Level 1: Main. This menu level contains five options. The *GENESIS* option transfers the user to the SMS Level 2 menu: GENESIS. The *RCPWAVE* option transfers the user to the SMS Level 2 menu: RCPWAVE. The *Utilities* option transfers the user to the SMS Level 2 menu: Utilities. The *Configure* option initiates execution of a command file that allows the user to install (or configure) the programs SMS.EXE (the SMS controller program),

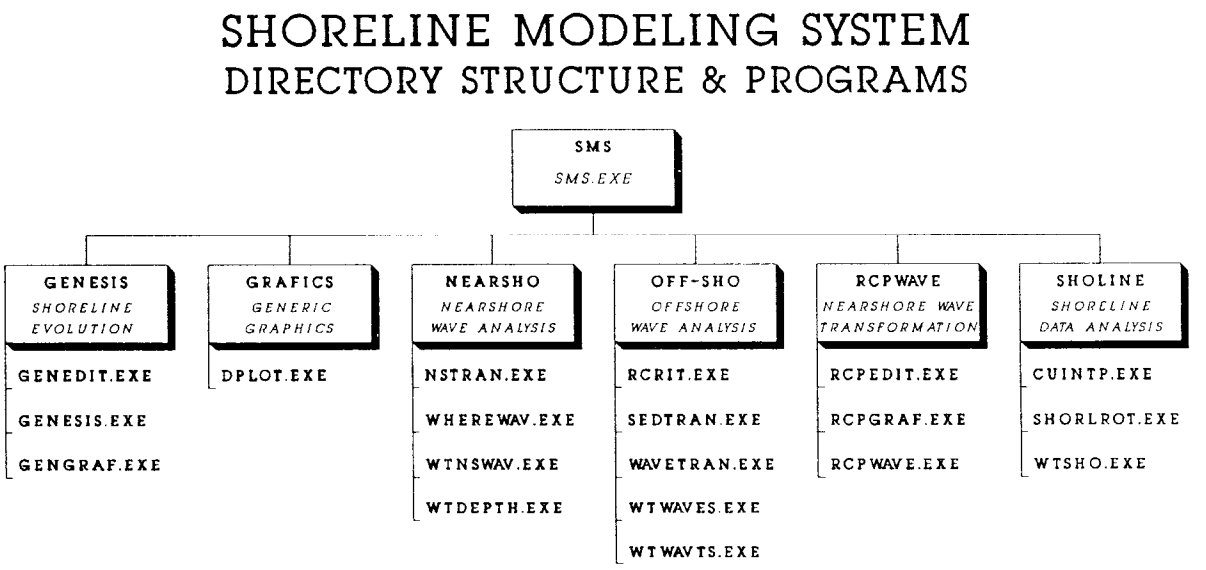

Figure 1. Directory structure of the SMS.

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SMS Level 1 menu:  Main
   GENESIS        RCPWAVE        Utilities        Configure        Exit
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(a) Level 1 menu

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SMS Level 2 menu:  GENESIS
   GENESIS        GENGRAF        GENEDIT          Exit

SMS Level 2 menu:  RCPWAVE
   RCPWAVE        RCPGRAF        RCPEDIT          Exit

SMS Level 2 menu:  Utilities
   Shorelines     Waves          Graphics         Exit
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(b) Level 2 menus

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SMS Level 3 menu:  GENESIS-Graphics
   Net Transport Rate   Shoreline Change   Shoreline Positions   Exit

SMS Level 3 menu:  RCPWAVE-Graphics
   2-D RCPWAVE Grid   Nearshore Reference Line   Exit

SMS Level 3 menu:  Utilities-Shorelines
   SHORLROT       CUINTP         WTSHO            Exit

SMS Level 3 menu:  Utilities-Waves
   Offshore Analysis        Nearshore Analysis        Exit
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(c) Level 3 menus

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SMS Level 4 menu:  Utilities-Waves-Offshore
   WAVETRAN    SEDTRAN    RCRIT    WTWAVTS    WTWAVES    Exit

SMS Level 4 menu:  Utilities-Waves-Nearshore
   WHEREWAV    WTNSWAV    WTDEPTH    NSTRAN    Exit
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(d) Level 4 menus

Figure 2. SMS menu levels and menu options.

GENGRAF.EXE (the GENESIS specific graphics program), RCPGRAF.EXE (the RCPWAVE specific graphics program, and DPLOT.EXE (the general purpose graphics program) to their specific PC environment (e.g., VGA monitor, HP laser printer, etc.). The *Exit* option terminates the SMS session.

SMS Level 2: GENESIS. This menu level contains four options. The *GENESIS* option initiates execution of the shoreline evolution model GENESIS. The *GENGRAF* option transfers the user to the SMS Level 3 menu: GENESIS-Graphics. The *GENEDIT* option initiates execution of the START.ext file editor, which enables generation or modification of the GENESIS input file START.ext. The *Exit* option transfers the user to the SMS Level 1 menu: Main.

SMS Level 2: RCPWAVE. This menu level contains four options. The *RCPWAVE* option initiates execution of the monochromatic nearshore wave transformation model RCPWAVE. The *RCPGRAF* option transfers the user to the SMS Level 3 menu: RCPWAVE-Graphics. The *RCPEDIT* option initiates execution of the RCPWAVE input file editor, which enables generation or modification of the primary RCPWAVE input data file. The *Exit* option transfers the user to the SMS Level 1 menu: Main.

SMS Level 2: Utilities. This menu again contains four options. The *Shorelines* option transfers the user to the SMS Level 3 menu: Utilities-Shorelines. The *Waves* option transfers the user to the SMS Level 3 menu: Utilities-Waves. The *Graphics* option initiates execution of the general purpose graphics and DOS operations program DPLOT (from HGRAPH version 5.1). The *Exit* option transfers the user to the SMS Level 1 menu: Main.

SMS Level 3: GENESIS-Graphics. From this menu the user can graphically post-process results previously generated by GENESIS. Current GENESIS user's will be familiar with this graphics system since it previously has been released as the GENESIS Data Visualization System. Three types of plots can be processed using options in this menu level. The *Net Transport Rate* option displays the average annual net longshore sand transport rate computed over the simulation period together with the average annual net longshore sand transport rate for the entire simulation reach (a straight line average for the simulation reach). The *Shoreline Change* option allows the user to display the computed shoreline change between the final computed shoreline position and the initial shoreline position, or the measured shoreline position, or an external (user specified) shoreline position data file. The *Shoreline Positions* option enables the user to plot the initial and calculated shoreline positions together with the specified coastal structures simulated including beach fills, seawalls, groins, and detached breakwaters. Additional shorelines such as the measured shoreline position, the seaward-most computed shoreline position, the landward-most computed shoreline position, the intermediate shoreline positions (specified in the START.ext file), and external (user specified) shoreline position data files also can be displayed. The *Exit* option transfers the user to the SMS Level 2 menu: GENESIS.

SMS Level 3: RCPWAVE-Graphics. From this menu the user can graphically post-process results previously generated by RCPWAVE. Two types of plots can be generated from within this menu level. The *2-D RCPWAVE Grid* option enables the user to display contour plots of the water depth, wave height, or wave angle on the two-dimensional RCPWAVE computational grid. Additionally, transects in the offshore direction can be selected from the contour plot and displayed in an XY-type plot (e.g., from the depth contour plot, profile lines can be selected and plotted separately). The *Nearshore Reference Line* option enables the user to plot both wave heights and wave angles along the nearshore reference line. Information (wave heights and angles) on the nearshore reference line (oriented in the longshore direction) are used by GENESIS to define nearshore wave conditions. The *Exit* option transfers the user to the SMS Level 2 menu: RCPWAVE.

SMS Level 3: Utilities-Shorelines. This menu level contains three generalized programs which enable the user to perform the shoreline position data analysis procedures (see Gravens 1991 and Gravens, Kraus and Hanson 1991) required to generate the two shoreline position data files necessary to perform a GENESIS simulation. Figure 3 provides a flow chart of the shoreline data preparation procedure. The *SHORLROT* option initiates execution of the SHORLROT program which performs a coordinate system rotation and origin translation on digitized X-Y shoreline position data. This procedure is typically required to map the digitized coordinate system into the GENESIS coordinate system . The *CUINTP* option initiates execution of the program CUINTP which uses a cubic spline interpolation algorithm to interpolate uniformly spaced shoreline positions from the rotated data. The *WTSHO* option initiates execution of the program WTSHO which reads the shoreline position data generated by the program CUINTP and writes a shoreline position data file for input to GENESIS. The *Exit* option transfers the user to the SMS Level 2 menu: Utilities.

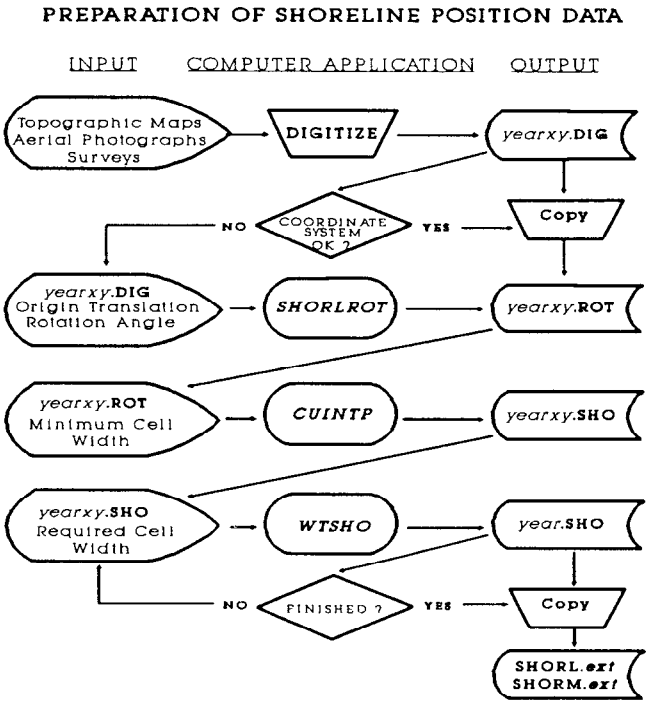

Figure 3. Shoreline data preparation procedure

SMS Level 3 menu: Utilities-Waves. This menu level has 3 options. The *Offshore Analysis* option transfers the user to the SMS Level 4 menu: Utilities-Waves-Offshore. The *Nearshore Analysis* option transfers the user to the SMS Level 4 menu: Utilities-Waves-Nearshore. The *Exit* option transfers the user to the SMS Level 2 menu: Utilities.

SMS Level 4 menu: Utilities-Waves-Offshore. This menu level contains five generalized programs which enable the user to process offshore wave data for input to GENESIS, to compute potential longshore sand transport rates from the offshore wave data, and to develop a regional sediment budget (see Gravens 1991 and Gravens, Kraus, and Hanson 1991). Figure 4 provides a flow chart of the offshore wave data analysis procedure and indicates the interaction between and usage of programs available within this menu level. The *WAVETRAN* option initiates execution of the program WAVETRAN which performs a Wave Information Study (WIS) Phase III-type transformation on the input time series according to user specified constraints. The *SEDTRAN* option initiates execution of the program SEDTRAN which computes potential longshore sand transport rates from the input time series of wave conditions. The *RCRIT* option initiates execution of the program RCRIT which processes the input time series of wave conditions and effectively eliminates from the time series those wave conditions which are either propagating offshore, calm, or are determined to be insignificant in terms of their ability to produce longshore sand transport rates sufficient to impact long-term shoreline change (Kraus, Hanson, and Larson 1988). The *WTWAVTS* option initiates execution of the program WTWAVTS which can be used to either select and write (to a new file) a subset of the input time series, or to append two or more input time series of wave conditions together. The *WTWAVES* option initiates execution of the program WTWAVES which enables the user to reformat an input time series of wave conditions for use as input to GENESIS. The *Exit* option transfers the user to the SMS Level 3 menu: Utilities-Waves.

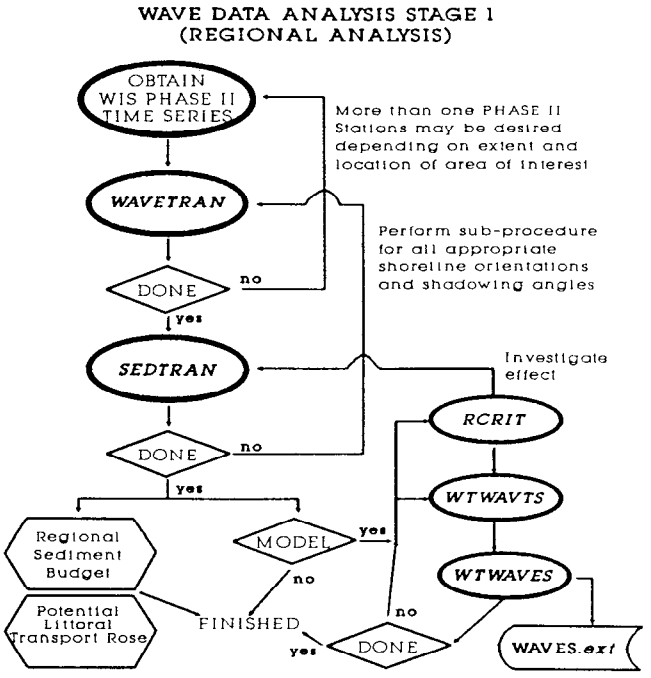

Figure 4. Offshore wave data analysis procedure

SMS Level 4 menu: Utilities-Waves-Nearshore. This menu level contains four generalized programs which enable the user to analyze an offshore time series of wave conditions to determine what nearshore wave transformation simulations should be performed, to process nearshore wave data (specifically output from RCPWAVE) for input to GENESIS, and to compute potential longshore sand transport rates using an offshore time series of wave conditions, a nearshore wave data base, and nearshore reference water depths to develop a local (or project level) sediment budget (see Gravens 1991, and Gravens, Kraus, and Hanson 1991). Figure 5 provides a flow chart of the nearshore wave data analysis procedure and indicates the interaction between and usage of the programs available within this menu level. The *WHEREWAV* option initiates execution of the program WHEREWAV which computes height, period, and angle of approach statistics of an input time series of wave conditions. These statistics are subsequently used to determine what nearshore wave transformation simulations are required to describe, in general, the transformation of the input time series over a digitized bathymetry to nearshore (near-breaking) conditions. The *WTNSWAV* option initiates execution of the program WTNSWAV which reads output (wave height and angle of approach data along the user specified nearshore reference line) generated by RCPWAVE and writes a data base of nearshore wave information for input to GENESIS. The *WTDEPTH* option initiates execution of the program WTDEPTH which reads output (water depths along the nearshore reference line) generated by RCPWAVE and writes a DEPTH.ext file for input to GENESIS. The *NSTRAN* option initiates execution of the program NSTRAN which computes potential longshore sand transport rates from an input time series of offshore wave conditions, a nearshore wave data base, and nearshore reference water depths (DEPTH.ext file). Output from this program can be use to develop a local (or project level) sediment budget. The *Exit* option transfers the user to the SMS Level 3 menu: Utilities-Waves.

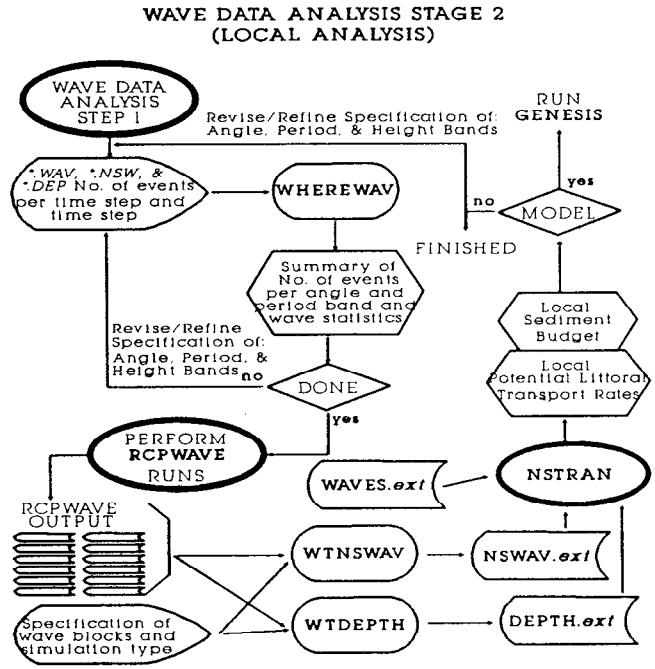

Figure 5. Nearshore wave data analysis procedure

SUPPORT: Services and products provided to Corps users of the SMS include training workshops, consulting services and user's manuals (Gravens in prep). Training Corps personnel on the usage of the SMS, and specific computer programs and numerical models within SMS, is accomplished via periodic workshops. Currently, CERC provides limited consulting services to Corps personnel performing model applications via the Numerical Model Maintenance Fund. More intensive training can be provided as part of joint field applications between CERC and Corps elements.

AVAILABILITY: The SMS will be released to the Corps for beta-testing at the SMS workshop in November 1991, and will be available to all Corps elements after the workshop. All the computational elements of the SMS are presently available. The SMS is designed to be run on a minimum hardware configuration of an IBM PC-AT machine with 640 Kb memory and a math

co-processor. The various menus and graphics produced by the system are in color and do not require additional commercial software. A color adaptor and VGA monitor are preferred, however, most EGA and CGA monitors will also work.

Copies of the SMS and consulting services concerning usage of the system the can be obtained by Mr. Mark B. Gravens, Coastal and Hydraulics Laboratory (601) 634-3809, *Mark.B.Gravens@erdc.usace.army.mil*.

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